B-167

FERTILIZERS and Their Use

TEXAS AGRICULTURAL EXTENSION SERVICE
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ON THE COVER

Fertilizer distributor for applying phosphate and lime broadcast on surface of land. Later these will be worked into the soil.

FERTILIZERS

. . . and Their Use

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Plants are much like human beings. They need air to breathe, water to drink and food to help them grow and reproduce. Take any one of these away and the plants will wither and die.

Where air and water are in balance, plant food —or fertilizer—is then and only then utilized by the plant and can be said to improve the soil.

FIRST USES OF FERTILIZERS

For more than 4,000 years, farmers used fertilizers to increase their crop yields. The Chinese, Greeks and Romans used animal manures, marl, chalk and wood ashes. They had no knowledge of the chemistry of soils and fertilizers to guide them, but they knew that animal residues and manures increased plant growth. Not until early in the 19th Century did man really know why organic matter and animal manures increased yields.

At that time it was shown that the chemical elements in organic residues—and not the organic matter itself—increased plant growth. Organic residues always have been good sources of plant food elements. Since they were once living material, they contain in fairly good balance the elements essential for plant growth. Organic residues, then, constituted the first fertilizers in agriculture.

When white men came to America, Indians were placing a fish under each hill of corn at planting time. They had learned that often this practice meant the difference between a crop and no crop. They knew also that certain sizes of fish should be used and that placing them in the hill at planting time was better then putting the fish on top of or in the ground after the corn had begun to grow. Today, we know that the fish added considerable nitrogen and phosphorus to the soil and that time had to be allowed for its decomposition, which made these nutrients available to plants.

America's first use of fertilizers. (Squanto, the first demonstrator.)

The first commercial fertilizers were used about 1830, when Chilean nitrate was imported. The guanos from Peru were brought in also and these two materials helped the farmer to learn the general values of fertilizers and to stimulate further development of the fertilizer industry. In 1868 the production of superphosphate from chemicals commenced in Baltimore. For many years thereafter, the fertilizer industry remained largely a salvage outlet for waste products from meat-packing plants, fish canneries and oil-seed industries.

Invention of two processes made it possible for the fertilizer business to grow into a large chemical industry. These processes were: (1) the recovery of ammonia from by-product coke ovens, and (2) the chemical fixation of nitrogen from the air.

In the past 10 years, fertilizer usage in the United States has doubled and the total consumption is now more than 20 million tons annually. Increased demands have made fertilizer manufacturing one of the largest chemical industries in the nation.

A knowledge of the values of plant foods in fertilizers, and the particular benefits from each, can bring about a more economical and more efficient use of this important aid to agriculture.

PLANT NUTRIENTS

Many nutrient, or food, elements are required for the normal development of plants. If any of these elements are low or lacking the plant either will not grow or will grow very poorly. These necessary elements are shown in the table below.

Three of these elements are obtained from air and water. The carbon comes mainly from the air, the hydrogen from water, and oxygen from both air and water. So plenty of water is necessary if the plant is to grow rapidly. Since roots breathe the oxygen in the soil atmosphere, too much water in the soil will drive out the oxygen, suffocate the plant, and possibly kill it.

MAJOR NUTRIENTS

The major elements of the soil required for plant development in relatively large quantities are nitrogen, phosphorus and potassium. Since the nutrient food element, or elements, most likely to be deficient will be one or more of these, they are known as the major nutrient elements. Nitrogen is taken from the soil by most plants either in the ammonium or nitrate form. Legumes, properly inoculated and growing under favorable conditions, obtain a large part of the nitrogen they need from the air through the nodule-forming bacteria. Phosphorus comes from the soil and is taken up by the plant in the form of phosphates. Potassium is taken from the soil solution in the form of soluble potassium compounds.

SECONDARY ELEMENTS AND SOIL AMENDMENTS

Calcium, magnesium and sulfur are essential plant nutrients but usually are present in the soil in sufficient quantities to meet the nutritional needs of the plants and to stimulate necessary growth of micro-organisms. Their greatest use, however, is as soil amendments. Amendments improve tilth or structure of the soil thereby allowing the desired balance, between air, water and nutrients. If calcium is so deficient as to limit plant growth, the soil probably is acid. Lime (calcium limestone) will sweeten the soil, condition it and act as a fertilizer to supply calcium all at the same time.

A soil low in magnesium produces definite growth symptoms in plants. Dolomite, which contains both calcium and magnesium, is one of the best sources of magnesium for the soil. Magnesite may also be used. In some areas application of Epsom salts has proved helpful.

Generally speaking, lime and dolomite are not needed in the western part of the State where soils usually are high in calcium and magnesium.

Sulfur is applied as an amendment to soils which are too alkaline. It oxidizes (combines with oxygen) in the soil to form sulfuric acid. The acid reduces the alkalinity or increases the acidity, thus improving growing conditions. In some cases, sulfur is low in the soil and must be applied to meet the nutrient requirement of plants. Usually sufficient sulfur for nutrient purposes will be obtained by the plants from the calcium sulphate contained in the superphosphate where this material is used.

ESSENTIAL PLANT NUTRIENTS

Elements from air and water	Elements from the soil			
	Major elements	Secondary elements and amendments	Trace elements	
Carbon Hydrogen Oxygen	Nitrogen Phosphorus Potassium	Calcium Magnesium Sulfur	Iron Manganese Copper Chlorine	Boron Zinc Sodium
Constitute approximately 95% of plant weight	Constitute approximately 5% of plant weight			

TRACE ELEMENTS

Since some elements are needed by plants in very small quantities, they are called trace, minor, or micronutrient elements; but they are just as necessary to plant development as are the major elements. When in the soil solution, they are available to plants. They may be applied to the soil in the pure form or with fertilizers. Soluble iron perhaps is needed more than any of the other trace elements. It is the specific treatment for chlorosis, the yellowing of leaves of plants growing in soils that are too alkaline or have large quantities of limestone. The alkalinity of the soil reduces the availability of the iron to plants. Iron can be applied in the form of an iron solution spray on the leaves of the growing plants for immediate, temporary relief (1 pound of iron sulfate to 50 gallons of water or 1 ounce to 3 gallons of water). For longtime effect, it should be applied in the soil at frequent intervals in bands near and around the plants.

The other trace elements—zinc, copper, manganese and boron—may be applied to the soil or sprayed on the plants when needed to correct nutritional disturbances.

EFFECT OF NUTRIENTS ON PLANT GROWTH

The presence or absence of a certain plant nutrient has a definite effect on plant growth. Application of one element usually will not substitute for the shortage of another.

Effects of Nitrogen

1. Encourages vegetative growth.
2. Causes a deep-green leaf color by increasing chlorophyll.
3. Increases plumpness and protein of grain.
4. Produces succulence in crops such as grass, lettuce, radishes, etc.
5. In excessive quantity:
   a. Produces a delayed maturity.
   b. Increases tendency to lodge.
   c. Increases susceptibility to diseases.
   d. Decreases resistance to drouth.
   e. Causes sappy growth and promotes winter killing.
   f. Causes plant to fail to set fruit.
   g. Causes fruit to be watery and of poor quality.
6. A deficiency of available nitrogen results in stunted plants with restricted root system. The leaves turn yellow or yellowish-green and drop off some plants. Yields and quality are reduced.

Effects of Phosphorous

1. Encourages root growth, especially the lateral and fibrous rootlets.
2. Hastens maturity of the crop; flowering and fruiting depend on it.
3. Increases the ratio of grain to straw as well as total yield of grain.
4. Improves quality of crops.
5. Increases disease resistance.
6. Is essential to seed production.
7. Aids in formation of carbohydrates.
8. Aids in assimilation of fats.

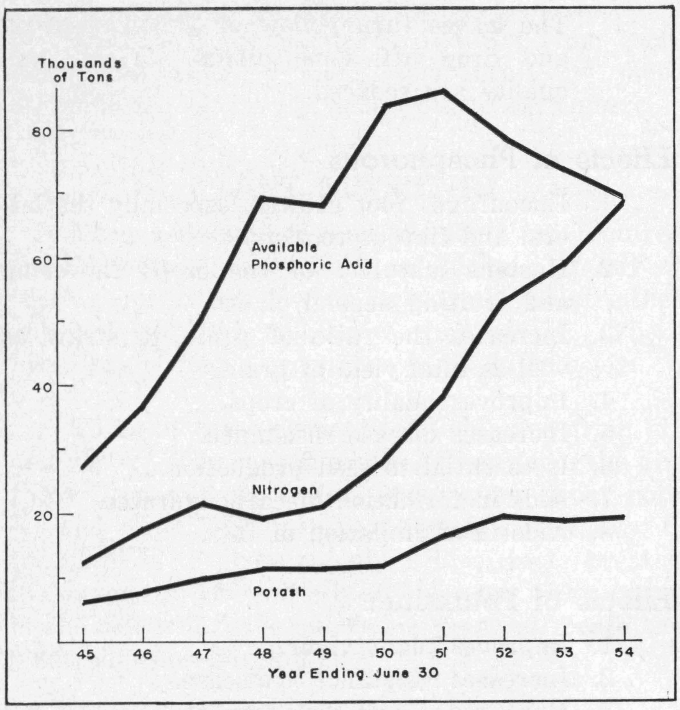
Effects of Potassium

1. Improves plant vigor.
2. Increases resistance to disease.
3. Encourages root development.
4. Delays maturity, thus balancing the effect of phosphorous.
5. Gives plump, heavy kernels in grain.
6. Encourages tuber development.
7. Is needed in the development of chlorophyll.
8. Offsets bad effects of excessive nitrogen and phosphorous.
9. Increases drouth resistance.
10. Increases sugars and starches.

Effects of Calcium

1. Encourages root growth.
2. Promotes leaf growth.
3. Is necessary for nodulation of legumes.

Experimental machine for applying various amounts of fertilizer and seeding simultaneously.



Primary components sold in Texas, 1944-54.

Effects of Magnesium

1. Is necessary for chlorophyll formation.
2. Encourages vegetable oil formation in plant and seed.

Effects of Sulfur

1. Increases root system.
2. Promotes formation of chlorophyll.
3. Increases nodulation of legumes.

Effects of the Trace Elements

(Minor Elements, Micronutrients)

1. Iron—promotes formation of chlorophyll.
2. Manganese—promotes formation of chlorophyll, sugar and proteins.
3. Boron is necessary for nodulation of legumes, helps growth of growing tips of branches and roots.
4. Zinc is necessary for chlorophyll formation.
5. Copper is necessary for cholorphyll formation.

Since several of the elements have the same job in developing a plant, it is often hard to decide which is lacking when something goes wrong. For example, magnesium, sulfur, zinc, copper, iron and manganese help make chlorophyll. When plants develop a pale yellow, or chlorotic, appearance, it is difficult to decide which nutrient element is lacking by noting this one symptom. It is necessary to check the plant as a whole, studying all of the symptoms and all of the developments, before deciding for sure what is responsible.

Not only must all elements be present but also in balance so that the plant will be able to absorb them in the proper proportion. Large quantities of some trace elements may have serious effects on plants and may reduce yields or even kill the plants.

Plant nutrients are necessary not only for the best development of growing plants but also for the best development of micro-organisms in the soil. A shortage of some elements may slow the development of the micro-organisms. Here again, the right amounts of the nutrients are necessary—neither too much nor too little—for best results in both plant and micro-organism growth.

Tremendous quantities of the major nutrients are required to produce the crops now being grown in Texas. As virgin soils lose their natural supplies of the nutrients, reinforcement by fertilizers becomes increasingly necessary.

Commercial fertilizers are applied primarily to add to the supply of plant nutrients already in the soil and not as the only source. The amount used varies, depending on the needs of the crops grown, soil bacteria and of the soil itself, with increased crop yields and better quality as the goal.

PLANT FOOD REMOVED BY SOME CROPS

Certain crops remove more plant food from the soil than others. As a rule the more of the crop removed from the land, the greater the quantities of plant food removed. Forage crops remove large amounts of nitrogen, potassium and calcium. Grain crops take out large amounts of nitrogen and phosphorus. Legume crops remove large amounts of phosphorus, magnesium, sulphur, potassium and calcium. Unless these legume crops are turned under as green manure or the residues and animal manures are returned to the soil, they deplete rather than build soil. Nitrogen in legume crops comes partly from the air and, therefore, is not a full loss when the crop is harvested. When legumes are properly fertilized, they improve the nitrogen and organic matter supply of the soil. When legumes are grown in rotation and sufficient amounts of phosphate and potash are applied, they usually will increase the yields of harvested crops.

Vegetable crops generally remove large amounts of nitrogen, phosphorus and potassium; high rates of complete fertilizer applications are desirable.

The table below shows approximate amounts in pounds per acre of the major and secondary plant foods removed by standard yields of standard crops.

A soil should contain several times the amount of plant foods removed by crops in an available form for good crop growth. These amounts of plant foods removed may vary as much as 100 percent depending upon crop variety, fertilizer treatment and soil conditions.

For some of these crops not all the vegetative or above ground growth was used in calculating the amount of plant food removed. In no case was the plant food requirement of roots considered. These roots, as well as the soil micro-organisms which decompose the roots, require plant food.

DETERMINING THE NEED FOR NUTRIENTS

Productivity of soil involves many factors other than the quantity and availability of plant nutrients. Some causes of poor plant production are: lack of drainage, resulting in a water-logged condition; unfavorable temperature; poor physical condition of the soil; drouthy soils; too much alkali; too much acid; too much lime; and hard pans or clay pans near the surface. Such defects, coupled with a depletion of the plant nutrients, add up to lower production.

The first step in analyzing the problem of poor plant production is a careful examination of the soil itself. Is the structure and texture suited to the crop to be grown?

Next, check the subsoil. Is there a hard pan near the surface? Then, look over the area. Are there alkali or water-logged spots?

Insofar as possible, check the history of the particular soil. What has it grown in the past? How successfully? Were any deficiencies indicated in previous crops?

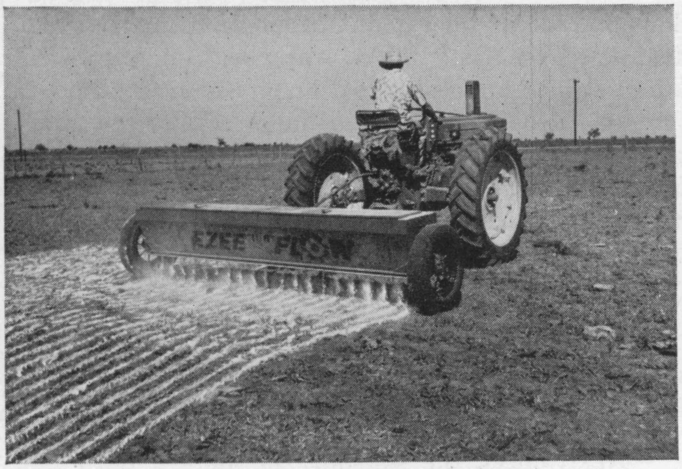
Answers to these questions can give a good picture of the production possibilities.

NUTRIENTS REMOVED BY CROPS IN POUNDS (Approximate)

Crops	Acre Yield	Major Plant Foods			Secondary Plant Foods		
		Nitrogen	Phos. Acid	Potash	Calcium	Magnesium	Sulphur
Alfalfa hay	4 T.	190	51	223	160	27	23
Apples	400 Bu.	21	3	21	1	*1	
Cabbage	15 T.	100	26	98	22	5	35
Clover, red, hay	2 T.	80	20	79	61	15	6
Clover, sweet	3 T.	110	18	94	75	21	27
Corn, grain and stover	60 Bu.	93	44	55	14	16	13
Cotton, lint and seed	1,500 Lb.	38	18	18	2	4	3
Lespedeza, hay	3 T.	130	28	74	—	—	—
Oats, grain and straw	50 Bu.	47	17	46	6	8	8
Peanuts, nuts and vines	2,000 Lb.	174	35	86	74	21	18
Peas, vines and peas	5,000 Lb.	120	31	121	175	15	12
Potatoes, white tubers	400 Bu.	87	29	138	3	7	6
Potatoes, sweet tubers	300 Bu.	45	32	73	4	8	6
Soybeans, grain	30 Bu.	110	32	40	4	6	4
Soybeans, hay	2 T.	102	24	61	45	20	12
Tomatoes, fruit	10 T.	60	15	70	3	4	4
Wheat, grain	30 Bu.	34	17	11	1	3	3
Wheat, straw	1½ T.	15	6	36	7	3	5

— indicates there are no analysis data available.
* indicates a value of less than one.

Data from USDA Misc. Pub. No. 369, McVickar, "Using Commercial Fertilizer," and "The Peanut"—"The Unpredictable Legume."



Drill-type lime spreader.

SOIL TESTING IN LABORATORIES

A soil test will show the plant food available to the plants in the soil and in what proportion. The laboratories will report the number of pounds of plant nutrients per acre needed to give an approximate balance in the soil for the growing plant. Suppose a recommendation was 30-60-30 before planting and 60-0-0 as a sidedressing. This would mean application of 600 pounds of a 5-10-5 fertilizer or 300 pounds of a 10-20-10 fertilizer before planting and then one of the following as side-dressing: approximately 80 pounds of anhydrous ammonia, 200 pounds of ammonium nitrate, 300 pounds of ammonium sulfate or 400 pounds of nitrate of soda as a sidedressing.

Taken, alone, the information obtained in soil tests usually isn't enough for a final answer. But when it is considered along with the information obtained in the on-the-ground check (history, ease of handling, lay of the land and other physical characteristics), the soil test should help in planning crop production and general soil improvement.

For a soil analysis to be of value, the sample must be representative of the entire area. In one field or on one farm, there may be several types of soil. In such cases, a sample from each type should be tested. Samples should be gathered from several spots in any field.

If only small plots of land are involved, the samples may be taken from a relatively small area. On the other hand, if one area with a particular problem is to be tested, adjoining areas of the same soil type but not involved in the problem also should be tested.

This service can benefit farmers and every banker who deals with farmers, as well as entire agricultural communities. On the basis of soil test results, bankers now have a guide for lending operations which heretofore did not exist. Soil tests can, in fact, serve as a form of credit insurance.

FIELD TESTS

The final test in deciding which plant nutrient is lacking is a field test. These tests are the most valuable means of learning which nutrient element is lacking. A field test will indicate the best adapted fertilizer.

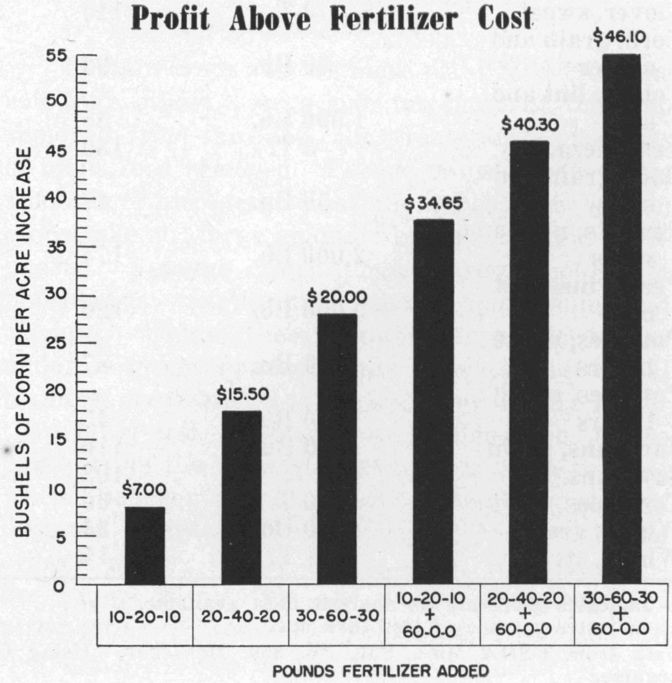
PLANT TISSUE TESTS

Testing the plant tissue itself in a laboratory or in the field actually can supply, in many ways, more accurate information than soil testing. But since the plant tissue test can be made only after the plant is growing, the answers may be too late for immediate help.

For testing plant tissue, parts of the leaves, petioles, or stems of the plants are chopped into small pieces and extracted with different solutions or the sap from the plant may be pressed out and tested. Those solutions are then tested for nitrates, ammonia, potassium, phosphorus and, sometimes, other nutrients.

The information is accurate—but, it may be too late to help this year's crop.

Profit Above Fertilizer Cost



A modern manure spreader.

METHODS OF APPLYING COMMERCIAL FERTILIZER

Fertilizers may be applied in any one of five ways:

1. Spread over the entire surface by broadcasting and plowing under. Recommended only for broadcast crops.
2. Applied in a small area close to the seed or plant by row or hill placement (best results have been obtained by applying the fertilizer about 2 to 3 inches to the side and 2 to 6 inches below the level of the seed with a fertilizer attachment on the planter).
3. Applied at the time of land preparation by an attachment placing the fertilizer on the plow sole (plow sole fertilizing will place the material about 8 or 10 inches deep).
4. Dissolved in irrigation water for application to the crops while irrigating.
5. Applied at time of cultivating crop with fertilizer attachment on cultivator.

The type of crop being grown generally will determine the method. Since hill or row placement concentrates the fertilizer in a band, it usually makes better use of fertilizer than the other methods. In addition, the greater concentration enables the crops to make fuller use of the nutrients.

DEFICIENCY SYMPTOMS OF PLANTS

Information obtained from a study of the soil alone, however, may not be enough. A careful study of the plants themselves will aid in deciding which nutrient elements are lacking. In the following outline, taken from Ohio State Agricultural Experiment Station Bulletin 611, signs indicating certain deficiencies are described. A study of the plants, based on these signs, plus a study of the soil itself will give the right answer in many cases. With that answer, the deficiency can be corrected.

A KEY TO NUTRIENT DEFICIENCY SYMPTOMS

A. Effects general on whole plant or localized on older, lower leaves.

1. Effects usually general on whole plant, although often manifested by yellowing and drying of older leaves.

   a. Foliage light green. Growth stunted, stalks slender and few new branches. Leaves small, lower ones lighter yellow than upper. Yellowing followed by a drying to a light brown color, usually little dropping of leaves. *NITROGEN DEFICIENT.*

   b. Foliage dark green. Retarded growth. Lower leaves sometimes yellow between veins but more often purplish, particularly on petiole. Leaves dropping early. *PHOSPHORUS DEFICIENT.*

Phosphate fertilizer increases yield of Hubam sweetclover. Fertilized plot is 2 feet high; unfertilized, 1 foot.

2. Effects usually local on older, lower leaves.

   a. Lower leaves mottled or freckled, usually with dead areas near tip and margins. Yellowing beginning at margin and continuing toward center. Margins later becoming brown and curving under and older leaves dropping off. *POTASSIUM DEFICIENT*.

   b. Lower leaves chlorotic and usually dead in late stages. Chlorosis between the veins, veins normal green. Leaf margins curling upward or downward or developing a puckering effect. Dead areas developing between the veins very suddenly, usually within 24 hours. *MAGNESIUM DEFICIENT*.

B. Effects localized on new leaves.

1. Terminal bud remaining alive.

   a. Leaves chlorotic between the veins, veins remaining green.

      i. Dead spots usually absent. In extreme cases death of margins and tip of leaf, sometimes extending inward, developing large areas. Larger veins only remaining green. *IRON DEFICIENT*.

      Note: Certain cultural factors, such as high pH, overwatering, low temperature, and nematodes on roots, may cause identical symptoms. However, the symptoms are still probably of iron deficiency in the plant due to unavailability of iron caused by these factors.

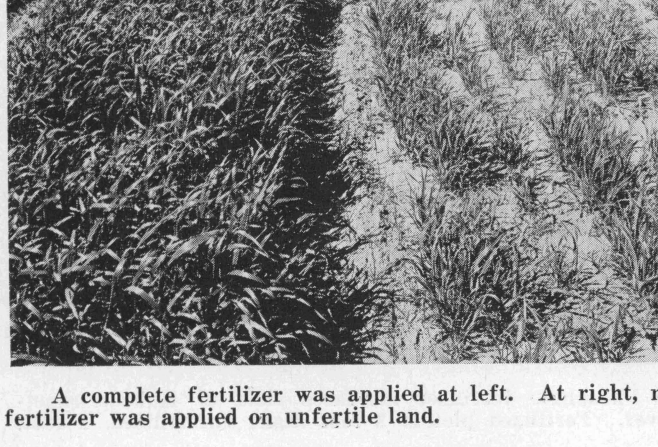
      ii. Dead spots usually present and scattered over the leaf surface. Checkered or finely netted effect produced by even the smallest veins remaining green. *MANGANESE DEFICIENT*.

   b. Leaves light green, veins lighter than areas between veins. Some dead spots. Little or no drying of older leaves. *SULFUR DEFICIENT*.

2. Terminal bud usually dead.

   a. Death at growing tip and margin of young leaves. Young leaves often definitely hooked at tip. Death of roots actually preceding all the above symptoms. *CALCIUM DEFICIENT*.

   b. Breakdown at base of young leaves. Stems and petioles brittle. Death of roots, particularly the root tips. *BORON DEFICIENT*.



A complete fertilizer was applied at left. At right, no fertilizer was applied on unfertile land.

BEHAVIOR OF NUTRIENTS IN THE SOIL

Different nutrients in a fertilizer behave differently in the soil. Nitrogen in the fertilizer can move freely with the soil moisture. Potassium moves a little less but does move with the soil moisture to the plant roots. In times of heavy rains or under heavy irrigation, these two may be lost by leaching. Since phosphorus fertilizers do not move very rapidly or very far, they should all be drilled into the soil deep enough to come into contact with the roots as they grow and develop. For that reason, phosphates are not usually as effective as side or topdressing as the nitrogen and potassium fertilizers. Always apply phosphates at, or just before, seeding time at the depth of the seed or below. The nitrogen and potassium can be added as a sidedressing later if needed.

One of the best methods of fertilizing is to use part of the fertilizer (particularly that containing large quantities of phosphate) at seeding, or just before, with enough nitrogen and potash to start the crop. Later, nitrogen and potassium can be added as a side or topdressing. Topdressing for small grains should be applied in the spring before the crop starts to joint. For corn, grain sorghums and similar crops, the sidedressing should be applied when the crop is about knee high. For cotton, tomatoes and other crops, the sidedressing should be applied about the time fruit begins to set, or shortly thereafter.

Fertilizer makes the difference.

A combination of the broadcast and row placement systems has been used successfully, especially when large quantities of fertilizer are used. Combinations of all methods also have proved successful under certain circumstances.

FERTILIZER MATERIALS

Fertilizer materials are derived from various sources. Each material from a particular source may have certain advantages and certain disadvantages. For example, nitrogen may be obtained from mineral salts such as sodium nitrate, ammonium sulfate, etc. or from sources such as barnyard manure or cottonseed meal. In the first case, nitrogen is immediately available, while in the latter, the manure or cottonseed meal has to rot and change before the nitrogen becomes available to the plants. Likewise, some of the fertilizer materials tend to make the soils more alkaline while others make them more acid.

MATERIALS FURNISHING NITROGEN

Ammonia Solutions or Liquid Ammonia

Ammonia solutions are made by dissolving ammonia and other nitrogen fertilizers in water. They are used by the fertilizer trade for making ammoniated phosphate. Ammonia solutions have been used in irrigation water for fertilizing crops, with satisfactory results. They may be applied directly on the land as fertilizer with equipment that will drill the solution in the ground.

Anhydrous Ammonia

Anhydrous ammonia is a good source of nitrogen fertilizer. Under ordinary conditions, ammonia is a gas containing about 82 percent nitrogen. When compressed it becomes a liquid and may be stored or shipped in high-pressure tanks. Machines and equipment have been developed for the direct application to the soil of anhydrous ammonia at the time of land preparation, planting or cultivating. In addition, it is dissolved in irrigation water for fertilizing crops in arid areas. Large amounts of ammonia may be lost to the acre when irrigation water flows long distances or where temperatures are high.

Ammonium Sulfate

This fertilizer is made by passing ammonia gas through sulfuric acid and then crystallizing the sulfate formed. Most of the ammonium sulfate originally was obtained as a byproduct of the coke ovens and gas plants. It may be made, however, by passing ammonia from the newer synthetic nitrogen plants into sulfuric acid, forming a white or gray crystalline salt which is highly soluble in water. It contains about 21 percent nitrogen and 24 percent sulfur.

When this fertilizer is applied to the soil, the ammonia is rapidly converted into nitrate which is readily taken up by the older plants. In the ammonium form, young plants and rice will take it up quickly. It is an intermediate acting nitrogen fertilizer and is the base for much of the nitrogen in mixed fertilizers. It tends to increase the acidity of soils when used for a number of years. It is highly recommended for alkaline soils and can be used in any area in the State, particularly in the rice area.

Ammonium Nitrate

Ammonium nitrate is a synthetic product manufactured at some of the plants built during the war. In the pure form, the salt is white and absorbs moisture rapidly. It usually is brought on the market as a brown or orange granulated material which has been treated to reduce the rate of moisture absorption from the air and to make it easier to apply. It usually carries about 33 percent nitrogen, one half as ammonium nitrogen and the other half in the form of nitrate. It is highly soluble in water. It is a rapid acting fertilizer, available to plants immediately upon application. A mixture of ground limestone and ammonium nitrate is marketed as a fertilizer containing about 20 percent nitrogen.

Ammonium Phosphate

There are two members of the ammonium phosphate family: mono-ammonium phosphate and diammonium phosphate. Both contain nitrogen and phosphate and are light-colored granular salts. They are produced synthetically. The mono-ammonium phosphate in pure form contains about 12 percent nitrogen and 62 percent phosphoric acid. The diammonium phosphate, contains about 21 percent nitrogen and 53 percent available phosphoric acid. They are soluble in water and readily available to plants. Three blends of ammonium phosphates that usually come on the market are 11-48-0, 13-39-0 and 16-20-0. These are a combination of one of the above ammonium phosphates and other materials, principally ammonium sulfate. These are concentrated fertilizer materials and may be used where nitrogen and phosphorus are required. "Ammoniated Superphosphates" are also available for direct soil application or making of mixed fertilizers. These are now available in the grades of 4-16-0 and 8-32-0.

Sodium Nitrate

Nitrate of soda, or sodium nitrate, comes from natural deposits in Chile, and also is manufactured. It is a white to gray salt, highly soluble in water and a quick-acting fertilizer. It carries about 16 percent nitrogen. Since it leaves an alkaline residue, it is probably best adapted to the acid soils in the eastern part of the State. Where the soils are already alkaline, continued use of sodium nitrate over a long period of years may be objectionable.

Calcium Nitrate

Calcium nitrate is a manufactured product, varying in color from white to brown. Since it takes water from the air rapidly, caking when exposed for any length of time, this material is treated to reduce moisture absorption. It carries approximately 17 percent nitrogen, largely in the form of nitrates. Since it is highly soluble in water and the nitrogen is in the nitrate form, it is a quick-acting fertilizer. It will have a neutral to slightly alkaline reaction in the soil. Since it is so likely to cake, very little is used in mixed fertilizers.

Calcium Cyanamid

Calcium cyanamid is a manufactured, black or dark gray, granular material and comes on the market containing about 21 percent nitrogen and 75 percent calcium. Since it contains lime, it slightly increases the alkalinity of the soil. Since it has a good physical condition and will run through ordinary fertilizer distributors freely, it is used in making mixed fertilizers. A slow acting fertilizer material, it should be applied at least two weeks before planting and should not come in contact with the seed or growing plants. When finely ground, it is used as a defoliant for removing cotton leaves before picking.

Urea

Urea is a synthetic fertilizer material. The nitrogen is in an organic form. It is a white or gray crystalline product containing about 46 percent nitrogen. It is easily soluble in water, the nitrogen converting into ammonia and finally into nitrate. Urea is a high analysis fertilizer material and is good for plants requiring large amounts of ammonia nitrogen. The effect of urea on the alkalinity or acidity of soil is slight. Urea has been used in water solution as a spray applied to foliage of crops. Some very favorable reports have been received from this method of application.

Guano

Guano is the name given to natural deposits of the excreta and dead bodies of birds and bats. It is usually found on the sea coasts and islands frequented by sea birds, and in caves occupied by bats. Several caves in Texas contain considerable amounts of this material. Its composition varies according to its purity, running from almost no nitrogen to 12 or 13 percent nitrogen. This nitrogen is in the form of ammonium salts and in organic combination. The phosphoric acid in guano varies from 6 to as much as 25 percent. Since it is so variable in composition, the value of a deposit cannot be judged from its appearance but only by chemical analysis. A good grade of guano is an excellent fertilizer.

Sewage Sludge

Sewage sludge is a product of sewage disposal plants. The nitrogen is in the organic form and is rather slow acting. Sewage sludge contains from 3 to 6 percent nitrogen and 2 to 4 percent phosphoric acid. It has a good physical condition and usually is easy to handle. It has a disagreeable odor when wet but has considerable merit for use in greenhouses, gardens, flower beds and lawns. It likewise finds its way into many special type fertilizers.

Manures

Sheep, hog, chicken and other manures are all valuable nitrogen fertilizers. They are marketed in a small way and are used in greenhouses and on lawns and gardens. They contain nitrogen in the ammonium form and in organic combinations. In

Good management and fertilizers are profitable.

many cases, phosphate and potash are added to increase their values.

Oil Meals

The oil meals consist of cottonseed meal, soybean meal, linseed meal and other products of similar nature. These vary from 6 to 8 percent nitrogen in organic forms and are slowly available. All are excellent fertilizers but are rather costly. Where meals unfit for animal feeding are available, however, they are a very valuable source of nitrogen fertilizer.

Miscellaneous Nitrogen Fertilizers

Leather scrap, hoof and horn meal, wool waste, feathers, silk waste and many other waste materials supply nitrogen in the organic form and are very slowly available. They are not considered of great value because of the slowness with which they become available. They are useful somewhat as fillers or in greenhouses or other special purposes.

MATERIALS FURNISHING PHOSPHATE

Rock Phosphate

Rock phosphate is found in many parts of the world. In this country the principal deposits are in Florida, Tennessee, South Carolina and the mountainous states of Idaho, Montana, Utah and Wyoming. The largest deposits of rock phosphate in this country lie in the western states, but the largest production now comes from Florida and Tennessee. Its purity varies. It is mined as hard rock phosphate, pebble phosphate, river pebble phosphate, fossil phosphate, boulder phosphate, sedimentary phosphate and apatite.

Rock phosphate in the pebble form is ground and may be put on the market untreated. Ground rock phosphate is of a light color and varies in composition from about 28 percent to 33 or 34 percent total phosphoric acid. Soft phosphate with colloidal clay is a product from the washings of the rock phosphate at the mines. It is dug up, dried, screened and brought on the market. This soft phosphate with colloidal clay contains about 20 to 22 percent total phosphoric acid.

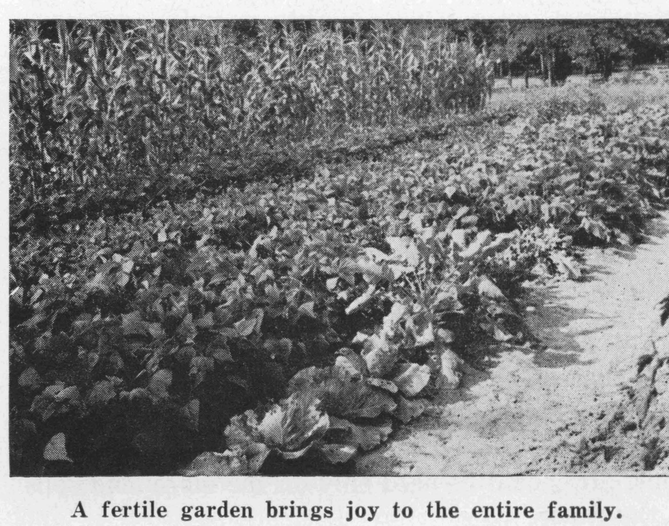
Rock phosphate and soft phosphate with colloidal clay have their greatest value in the more acid soils which are rich in organic matter. To derive comparable results from these slowly available phosphates, large quantities must be applied.

Superphosphate

Superphosphate is made from raw rock phosphate by treating it with acid. When sulfuric acid is used, the resulting product ranges from 16 to 22 percent total available phosphoric acid and contains considerable gypsum. Where phosphates are treated with phosphoric acid, the material is known as double superphosphate or triple superphosphate and will range from 40 to 48 percent available phosphoric acid. Both regular superphosphate and the double or triple superphosphate are excellent carriers of phosphoric acid for fertilizers. Both are recommended for use on the soils of Texas.

Fused Rock Phosphate

Fused rock phosphate is a new material not yet in general use. It is made by fusing rock phosphate with sand and is a dense gray material not soluble in water. It is free flowing. It offers promise for the future.



A fertile garden brings joy to the entire family.

Fertilizing a pasture with the drill-type distributor.

Calcium Metaphosphate

Calcium metaphosphate is comparatively recent development. It is made by treating rock phosphate with hot vapors from burning phosphorus, forming a molten product known as calcium metaphosphate which is glassy in appearance after cooling. This glass-like material is ground and marketed. It is a high analysis fertilizer carrying from 60 to 63 percent available phosphoric acid. Its effectiveness is about the same as superphosphate, and it may be used wherever phosphatic fertilizers are needed.

Phosphoric Acid

Phosphoric acid is a syrup, usually light-colored, and is marketed in drums. It ranges from 50 to 75 percent available phosphoric acid. It is being used as a fertilizer on irrigated farms where it is added to the irrigation water. Also, it may be applied to the soil directly.

Basic Slag

Basic slag is a byproduct of steel manufacturing. It is sold as a finely-ground, dark gray or brown powder with a phosphorus content ranging from 6 to 15 percent. The phosphorous in basic slag is more readily available than in rock phosphate. It is highly alkaline, containing large quantities of lime and magnesium, an added advantage on acid soils. This material has not been used to any great extent in Texas, largely because of supply limitations. It should be used only on the more acid soils of the State.

Bonemeal

Bonemeal is a byproduct of the packing houses. It is sold either as raw bonemeal or, more often, as steamed bonemeal. It contains some nitrogen in the organic form and ranges from 15 to 30 percent total phosphoric acid (usually about 20 to 22 percent). Because the phosphorus is slow to become available, its greatest use is in the greenhouses, around rose beds and with garden crops where slow, continued availability of phosphorus is required.

MATERIALS FURNISHING POTASH

Potassium Chloride (Muriate of Potash)—This is a high grade fertilizer varying from 48 to 62 percent water soluble potash (K_2O). The white crystalline material is easily applied and lends itself nicely to making mixtures. It is readily available to plants and is recommended for use wherever needed.

Potassium Sulfate (Sulfate of Potash)—This is a high grade fertilizer material varying from 48 to 50 percent potash. It is a neutral white crystalline salt readily available for use. It contains about 18 percent sulfur.

Kainit and Manure Salt—These are crude potash salts obtained from natural deposits or as byproducts in the manufacture of potassium chloride and potassium sulfate. As they come on the market they contain from 10 to 30 percent water soluble potash. They likewise contain varying quantities of magnesium.

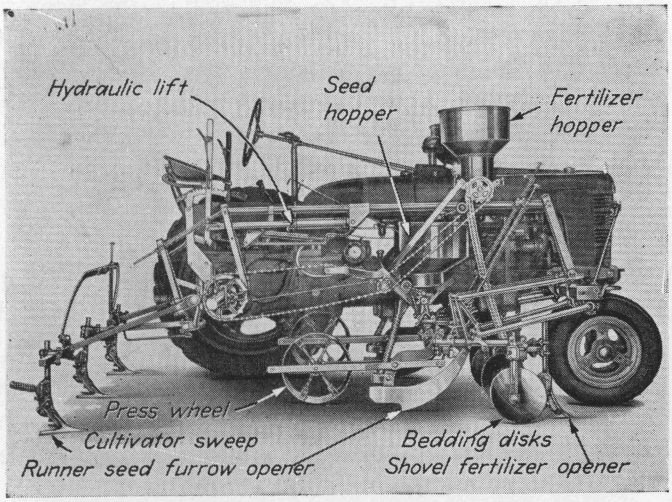
MATERIALS FURNISHING COMMON SOIL AMENDMENTS AND SECONDARY PLANT NUTRIENTS

Agricultural Lime

Ground limestone, ground oystershell, ground marl, builders lime and burnt lime are sold as agricultural lime. The value of agricultural lime lies in its purity (lack of clay, sand and excess water). The commercial products vary considerable as to the fineness and ease of distribution.

In Texas, there are large supplies of limestone that could be ground for use as agricultural lime. Likewise, large quantities of oystershell could be used for liming the soil.

Blackland soils and most of the soils in the western part of the State are somewhat alkaline and do not require lime. In the eastern part of the State



Modern planter and fertilizer distributor. The fertilizer attachment may be used at planting time or for sidedressing crops while cultivating. (Photo courtesy Texas Agricultural Experiment Station.)

and in the Gulf coast, however, there are large areas needing lime.

Magnesium

Dolomite is a hard, dense stone composed of approximately 45 percent magensium carbonate and 53 percent calcium carbonate. Small deposits of this material are found in several parts of the State. It is ground and distributed in the same manner as limestone and is the cheapest source of magnesium for agricultural purposes. Magnesite and langbeinite are natural carriers of magnesium that may be ground and distributed. In some areas, Epsom salts is beneficial where soils are low in magnesium where cost is not a factor.

Gypsum (Land Plaster)

There are large quantities of gypsum in the western part of the State. It is also obtained as a byproduct in manufacture of concentrated superphosphate. It is a good source of calcium and sulfur and may be used to furnish these two materials. It is neutral but will serve to reclaim alkali soils and improve the internal drainage of salty soils, when used in large quantities (10-15 tons per acre).

Sulfur

Sulfur is mined in Louisiana and Texas. For agricultural purposes, it is ground and marketed as agricultural sulfur, which is 98 percent or more pure sulfur. It oxidizes slowly to sulfuric acid and makes soils more acid.

MATERIALS FURNISHING TRACE ELEMENTS

Iron

The common source of iron is iron sulfate (copperas). Most soils contain an abundance of total iron but it is not always available to the plant. In some of our alkali soils (soils of high pH) plants often suffer from lack of iron. In such cases, iron sulfate may be applied to the soil or sprayed on the plant. On the other hand, the use of sulfur in the soil may make the iron more available and for this reason sulfur is beneficial in such cases. In addition, barnyard manure or green manure crops turned under will help to reduce iron deficiency. Beneficial results from the use of copperas will be had for a longer period if it is put in holes around plants having a deficiency than if it is worked into the soil.

Manganese, Zinc, Copper

The salts of these elements are applied to the soil or as a spray to the plants when needed. Copper sulfate (bluestone) is used commonly to supply copper. Bordeaux mixtures have copper in them and as a spray usually supplies the plant's need for copper. Zinc sulfate and manganese sulfate may be applied to the soil or as a spray to the plant.

Boron

Borax is used commonly to overcome a boron deficiency. Plants are sensitive to boron and care must be used to avoid an excess (not over 25 pounds of borax per acre).

MIXED FERTILIZERS

Mixed fertilizers are commercial products containing at least two, usually all three, of the major nutrients. Those containing all three major nutrients are called complete fertilizers; those containing only two, incomplete fertilizers.

Mixed fertilizers are manufactured by combining proper amounts of the different carriers of nutrients so as to give the desired composition. For example, ammonium sulfate, superphosphate and muriate of potash may be mixed to prepare a product containing all three of the major plant nutrients. Sometimes several carriers of plant food nutrients will be used in making a mixed fertilizer.

Occasionally some of the trace elements are placed in the commercial fertilizers. Where this is done, it becomes the basis for special advertising.

The amount of trace elements added per ton of fertilizer is usually small and may or may not meet the minimum demands of a soil in which an actual trace element deficiency occurs. Where trace elements are deficient, these nutrients should be applied directly rather than depending upon the small amounts in the mixed fertilizers.

Mixed fertilizers should contain 20 percent or more of the major nutrients. The lower the analysis of fertilizer, the more inert material the sack contains. It costs as much to process and transport inert materials as it does the fertilizer material in mixture. For example, one sack of 10-20-10 contains the same amount of nutrient elements as 2 sacks of 5-10-5 but one sack of 10-20-10 saves freight and handling charges on one sack of fertilizer.

Mixed fertilizers build up the nutrient levels in soils when two or three of the plant foods in the soil are low. The many mixtures and grades on the market permit the farmer to choose the one that fills his particular need. The advantages of using mixed fertilizers over different pure materials separately are: (1) a mixed fertilizer probably is easier to apply to the land with the present fertilizer distributing devices; (2) less care is required for even distribution and proper balance of the fertilizer than if the materials are applied separately; and (3) cost of application usually is less.

One big disadvantage in the use of mixed fertilizers is the tendency to go by brand names rather than to select a mixture best adapted to the area. Although some saving may be made by home mixing of fertilizers, competition among manufacturers keeps this saving at a minimum. Home mixed fertilizers usually have poor keeping and distribution qualities that offset savings. The main points to observe are: (1) know what your soil and crops need (have a soil test made); and (2) apply the amount of nutrients needed to give economical yields.

Fillers

Every sack of mixed fertilizer contains some material that is not utilized by plants. Some of these added materials help the fertilizer flow more easily through the drill and generally serve to maintain the condition of the fertilizer. The higher the fertilizer grade, however, the lower the amount of inert material. For example, a 5-10-5 fertilizer and a 10-20-10 fertilizer have the ratio of 1-2-1. Although 10-20-10 is more costly per sack, it contains less inert material and, depending on price, is a cheaper fertilizer in the long run.

In this connection, the fact that a fertilizer is not 100 percent plant nutrients does not mean that there is filler in the sack. For instance, pure sodium nitrate contains about 16 percent nitrogen. The remainder consists of those elements necessary to hold the nitrogen in a usable form and is not to be considered as filler. The same holds true for many other materials.

A sack of fertilizer may be said to have filler in it when worthless materials like sand are added for the purpose of making lower grade fertilizers.

Any specific claims made by the manufacturer with reference to the fertilizer will be on the tag. Everyone using fertilizer should read what the manufacturer says about his product.

Liquid Fertilizers

Recently a number of mixed fertilizers in liquid form have been brought on the market. These are solutions made up from various water-soluble carriers of the nutrients. The solutions may have the same nutrient ratios as the solid fertilizer. For example, the ratio may be a 10-20-10 (1-2-1) or it may be a 10-10-5 (2-2-1) or any other mixture.

Liquid fertilizers are usually more expensive than dry fertilizers.

METHODS OF APPLYING FERTILIZERS

Methods of applying fertilizers vary widely. On small gardens or lawns, fertilizer may be spread by hand and worked into the soil. For row crops, it is best to have equipment that will apply fertilizer in a band on one or both sides and below the seed at planting time. Applying fertilizer in the water furrow and bedding on it is another method that may be used.

Broadcast application should be used only for broadcast crops. Broadcasting fertilizer and then bedding on it stimulates weed growth which often reduces crop yields.

Sidedressings or topdressings should be applied early.

FACTORS INFLUENCING RESULTS FROM FERTILIZER USE

Fertilizers are applied to soils to increase crop yields.

If fertilizers are to produce the greatest increase in yields, the following must be favorable:

1. The fertilizer must be applied at proper time.

Equipment needed for applying anhydrous ammonia. (Courtesy of Tulsa Daily World.)

2. Crop must be adapted to area.
3. Insects and disease must be at a minimum.
4. Moisture must be adequate and rains timely.
5. Temperatures not too low nor too high for crop.
6. Soil structure should be good. This permits both air and water to enter the root zone freely. Soils with a granular structure produce better crops and respond to fertilizer better than if the soil is dense and compact. Legumes, grasses and crop residues plowed into the soil gives the soil a more granular structure.
7. A plow pan or compacted zone should be absent.
8. Other physical conditions should be favorable.

CROP REQUIREMENTS

Cotton

Cotton requires a soil of good moisture-holding capacity with good drainage and aeration. Soils for cotton need plenty of organic matter and well balanced in nutrients. Fertilizers can be applied in bands at the side of the seed at planting time, followed by nitrogen in the middle of the rows as a sidedressing when the cotton begins to fruit. If moisture is not available, sidedressing will not be profitable.

Corn

Corn needs plenty of readily available plant nutrients. It likewise requires large quantities of moisture and a deep, friable, permeable soil. During the latter part of growth, corn demands large quantities of readily-available nitrogen. For that reason, sidedressing corn when about knee-high is usually a good practice. Although corn requires plenty of water, too much will "drown" the corn, depleting the supply of oxygen and reducing the formation of nitrates from the organic matter.

Phosphorus deficiency in the soil usually shows up as a weak, slow-growing seedling. Soil deficient in potash shows in a rather weak stem, while soil lacking in nitrogen shows slow growth and a pale coloration in the leaves.

It is usually well to fertilize corn heavily with a complete fertilizer at or just before seeding and sidedress with some nitrogen fertilizer when the crop is about knee-high.

Grain Sorghums

Grain sorghums are tolerant of drier conditions than corn. Otherwise, the statements for corn hold for grain sorghums.

Small Grains (Barley, Oats, Rye, Speltz, Wheat)

Since small grains are best suited to a cool climate, they are planted usually in the fall in Texas. Small grains generally will grow in less fertile soil than corn, but on some of the more badly worn out soils, nitrogen and phosphorus are needed to insure a crop. Although small grains require an abundance of nitrogen, too much will cause lodging. For most of the soils in the State, topdressings of nitrogen fertilizers should be applied in the spring before the small grains begin to joint. In some areas, a treatment with a fertilizer containing nitrogen and phosphate is advisable in the fall at or just before seeding. This fall application is especially beneficial if the crop is to be grazed.

Rice

Rice is grown in soils with a tight sub-soil which will hold water in the irrigated sections of the Gulf coast. Although rice will produce moderate yields in less fertile soil than some of the other crops, application of nitrogen has been profitable throughout the entire area. In some cases both phosphorus and potash have shown profitable results, but where phosphorus has been used under poor crop management there has been an increase of grass and weeds in the rice with corresponding loss in yields.

Alfalfa and Sweetclover

Alfalfa and sweetclover are heavy users of phosphates, potash and lime. They grow best on deep, friable soils, well supplied with those three nutrients, and high in organic matter. They require a small amount of nitrogen in the fertilizer to start the seedling. After the seedling is well established no further nitrogen usually is required. Old stands are sometimes benefited by nitrogen. In addition, they require large quantities of water.

Other Legumes

All legumes are heavy users of phosphorus and potassium and lime. If the soils have enough potassium and lime a heavy application of phosphate is all that is required. If the soils have been worn out by continued cropping, a mixture of phosphorus and potassium in the fertilizer is justified for legumes of all types. Use of 20 percent superphosphate alone at the rate of 400 to 600 pounds per acre has increased tonnage of some of the pasture legumes as much as 50 percent. In other areas, 400 to 500 pounds of superphosphate and 100 pounds of muriate of potash or its equivalent are needed for the same results.

Pastures

In most areas, grazing has been limited to the abandoned areas on the farm. There is much more forage produced, per acre on fertile pastureland than there is on worn-out cropland. For this reason, it is particularly important that pastures have an adequate supply of all nutrients. Phosphorus is particularly important in pastures because of the demands of the better grasses and clovers for this nutrient. To meet this demand, it is suggested that phosphate fertilizer be applied as a base fertilizer before attempting to make a pasture. Potassium also aids in the development of these grasses. Nitrogen stimulates leaf growth and increases considerably the amount of grazing from a pasture.

When a pasture is being made, it is suggested that a complete fertilizer be applied, broadcast and plowed into the soil or drilled into the soil about 2 inches deep. After a pasture is established, annual applications of fertilizers rich in phosphorus should be made.

Peanuts

Peanuts are heavy users of potash and phosphorus. If inoculated, they gather nitrogen from the air, but the helpful effect of a small amount of nitrogen in the fertilizer at the time of planting speeds the growth of the peanut plant so it matures earlier and produces more heavily. Perhaps the best fertilizer for peanuts is 5-10-5 at seeding time. On soils particularly low in potash additional potash in the fertilizer is justified. For example, use 5-10-10.

Orchards

Bearing orchards need large quantities of nitrogen, phosphorus and potash. From the standpoint of orchard management, the most valuable single fertilizer element is nitrogen. Available nitrogen in the form of nitrates or ammonium salts at the time of blossoming adds greatly to the set of fruit. Nitrogen also stimulates growth for the development of fruit buds. It is also needed when a non-legume cover crop is plowed under to aid decomposition during the critical blossom time.

In addition to nitrogen, large quantities of phosphorus and potash must be added if either is deficient in the soil. In many cases a complete fertilizer is needed.

Truck Crops

Truck crops all require fertile soils with large quantities of organic matter and plant nutrients.

Usually it is profitable to apply half of the nitrogen and large quantities of phosphorus and potash, where needed, at planting time. The remainder of the nitrogen will be applied as a sidedressing at the time of most rapid plant growth.

Leafy and succulent vegetables require large quantities of nitrogen. Fertilizers for these should have a high nitrogen content or the plants should receive additional nitrogen as a sidedressing.

Root crops such as carrots, beets and onions are heavy users of phosphorus and potash. Fertilizers for these crops should furnish these required nutrients with sufficient nitrogen to insure good healthy plants. Seed and fruit producing vegetables such as peas, tomatoes and eggplants require large quantities of phosphorus and potash with enough nitrogen to give good vegetative growth and a healthy plant.

Flowers

Flowers require an open, well-drained, fertile soil, with all the nutrients in proper balance. If such soil is not available, large amounts of well-rotted compost should be added. For volume production of blooms on current growth, large quantities of nitrogen may be added as a topdressing after the buds begin to set. For plants that bloom on old wood, the soil requires large amounts of phosphorus and potash. Also, slightly to moderately acid soil is best for most flowers.

A good general fertilizer for flowers is 5-10-5 or 6-12-6.

Home Gardens

Vegetables grow best on deep, open soils, well supplied with humus and plant food. The soil for a good garden should be slightly acid.

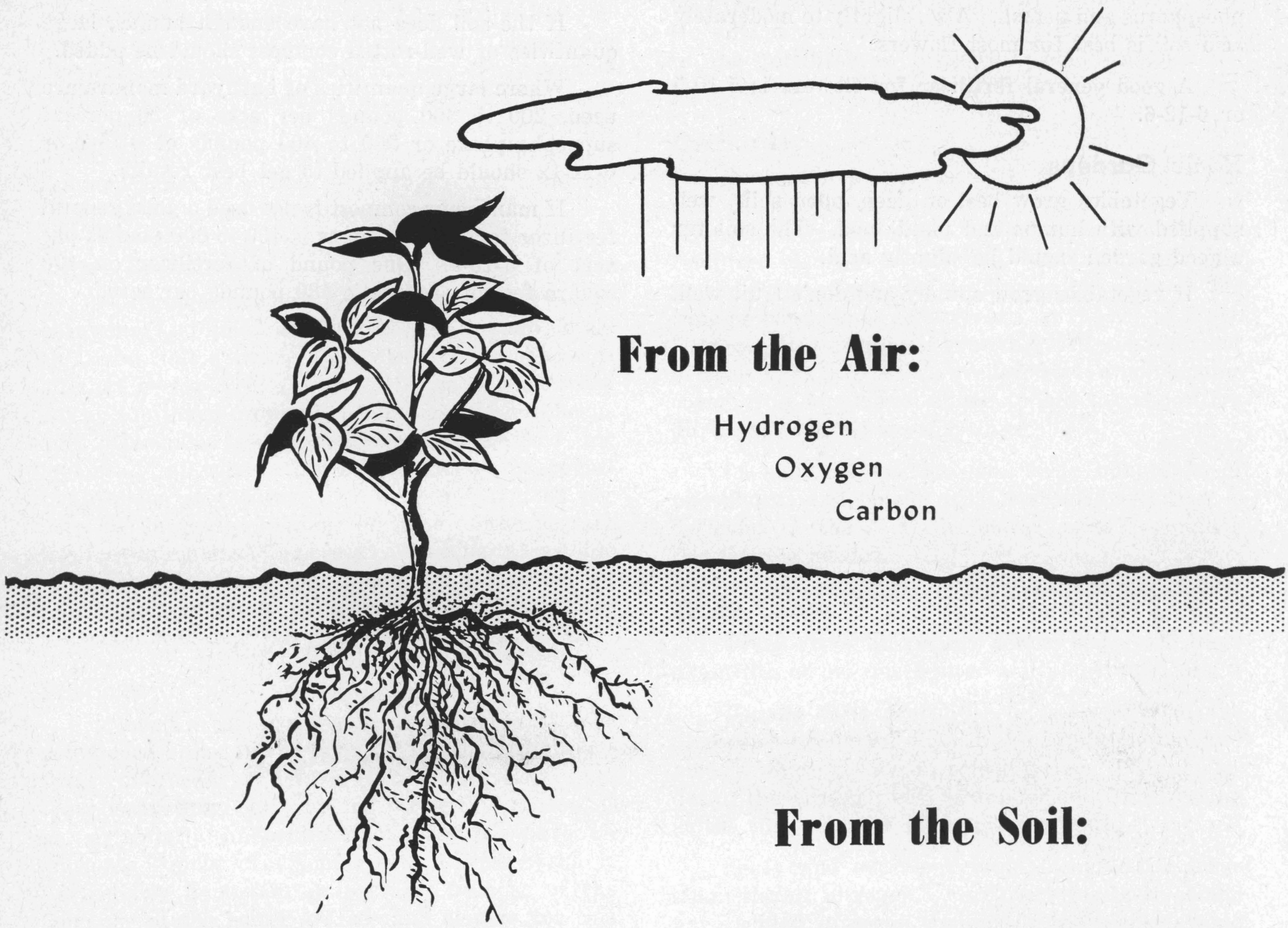
If vegetables grow spindly and don't fruit well, the fertilizer used should be rich in phosphoric acid and potash.

If the soil does not have enough humus, large quantities of well-rotted compost should be added.

Where large quantities of barnyard manure are used, 200 to 300 pounds per acre of 20 percent superphosphate or 300 to 400 pounds of 0-14-7 or 0-12-12 should be applied to get best results.

If manure or compost is not used a good general fertilizer for home gardens is 400 to 600 pounds per acre of 5-10-5. One pound of fertilizer on 100 square feet of surface is 430 pounds per acre.

Where A Plant Gets Its Food



PRIMARY PLANT FOODS

Phosphorus
Nitrogen
Potash

SECONDARY PLANT FOODS

Magnesium
Calcium
Sulphur

TRACE ELEMENT PLANT FOODS

Manganese, Cobalt, Zinc, Iron, Copper, Molybdenum, Boron, Iodine, etc.

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10—2-55, Revised.